

## **EXHAUST ASSEMBLY**

### **Field**

- 5           This invention relates to the field of exhaust assemblies, and more specifically to exhaust assemblies for marine engine applications.

### **Background**

- 10           In marine exhaust systems, a flexible exhaust hose is coupled between the combustion engine of a generator set (genset) and a muffler and water separator. These flexible exhaust hoses transfer the exhaust gases and the raw water from the genset to the boat muffler and water separator that are located remote from the genset. Unlike automotive exhaust system that are made of metal, which is a good noise barrier, marine exhaust hoses have to be flexible and thus are not good barriers  
15           for noise. Lately, genset noise has been reduced through better designs, thus making the radiated noise from the exhaust hose the major source of overall noise.

- One technique to reduce the noise of exhaust hoses is to insulate the exhaust hose with a barrier type material. However, this is not a practical solution since the boat builder supplies the exhaust hose and the builders are typically reluctant to  
20           invest the additional time and money to insulate the exhaust hose. What is needed is a more practical technique to reduce marine exhaust hose noise.

### **Summary**

- 25           A system includes a combustion engine having an exhaust to emit water and exhaust gases from the exhaust and a sound-dampening device coupled between the exhaust and a muffler. The sound-dampening device includes a tubular member having two or more internal rings.

In one option, the tubular member includes a flexible exhaust hose for coupling between the exhaust and the muffler, the flexible exhaust hose having an inner diameter, and the two or more rings are located on the inner diameter of the flexible exhaust hose, each ring having an outer diameter the same as the inner  
5 diameter of the flexible exhaust hose and an inner diameter smaller than the inner diameter of the flexible exhaust hose.

In one option, the tubular member includes a rigid tube having a first end connectable to the exhaust and a second end couplable to a flexible exhaust hose. The tube includes an inner diameter, the inner diameter having the at least two rings  
10 mounted thereto, each ring having an outer diameter the same as the inner diameter of the tube and an inner diameter smaller than the inner diameter of the tube.

### **Brief Description of the Drawings**

FIG. 1 shows a schematic view of a marine genset exhaust system in  
15 accordance with one embodiment.

FIG. 2 shows a side view of a genset having an exhaust assembly in accordance with one embodiment.

FIG. 3 shows an exploded view of the exhaust assembly of FIG. 2.

FIG. 4 shows a section view of an exhaust tube of FIG. 2.

20 FIG. 5 shows an end view of the exhaust tube of FIG. 4.

FIG. 6 shows a genset having an exhaust assembly in accordance with one embodiment.

FIG. 7 shows a side view of an exhaust hose in accordance with one embodiment.

25 FIG. 8 shows a section view of the exhaust hose of FIG. 7.

FIG. 9 shows a graph depicting exhaust system noise tests.

FIG. 10 shows another graph depicting exhaust system noise tests.

### **Detailed Description**

The following detailed description and accompanying drawings show various embodiments according to the inventive subject matter disclosed herein.

- 5 These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention. Other embodiments may be utilized and structural changes may be made without departing from the scope of the present invention.

Figure 1 shows a schematic view of a of a marine genset exhaust system in accordance with one embodiment. The figure shows a layout including a genset 10  
10 having an exhaust portion 20, a flexible marine exhaust hose 30, a muffler 40, and a water separator 50. The components are shown within a boat 2. The boat builder supplies and installs the genset and the exhaust system for the genset in boat 2. Genset 10 includes a combustion engine which produces and controls electricity to be used on the boat. In this example, an exhaust tube 100 is coupled between the  
15 exhaust portion 20 and the flexible marine exhaust hose 30. Exhaust gases and water from genset 10 are emitted from the genset through exhaust portion 20, into hose 30, and through muffler 40 and on to water separator 50.

Figure 2 shows a side view of genset 10. Exhaust portion 20 includes an elbow 105 having exhaust tube 100 mounted thereto by O-clamps 105. Exhaust  
20 tube 100 is a sound-dampening device that reduces the radiation of sound from standard marine hose 30 (Figure 1). The exhaust tube 100 does not affect the outer dimensions of the genset 10. In other words, a genset without tube 100 includes an exhaust portion that takes up the space of tube 100. Thus, the boat builder does not have to do any additional work or invest time and money in modifying the exhaust.

25 Figures 3-5 show further details of exhaust tube 100. Figure 3 shows an exploded view of portions of the exhaust assembly of Figure 2. Figure 4 shows a section view of exhaust tube 100. Figure 5 shows an end view of exhaust tube 100. Sound-dampening exhaust tube 100 includes a rigid tubular body having a first end

102 connectable to the exhaust elbow 105 and a second end 104 connectable to a standard flexible exhaust hose such as hose 30 (Figure 1). Tube 100 includes an inner diameter 124. Inner diameter 124 includes at least two constricting members such as rings 130, 140 mounted thereto, each ring 130, 140 having an outer diameter  
5 122 the same as the inner diameter 124 of the tube 100 and an inner diameter 126 smaller than the inner diameter 124 of the tube. In one embodiment, the respective rings are at opposite ends of tube 100 and are about 4 inches to 5 inches apart.

In one example, exhaust tube 100 is a two-inch diameter and five-inch long rigid metal pipe, such as a stainless steel tube. Rings 134, 140 can also be formed of  
10 stainless steel. The specific diameter and length of the rings 130, 140 and tube 100 can vary. The rings 130, 240 can be welded to the tube body 121.

Exhaust tube 100 reduces radiated noise from exhaust hose 30. Rings 130 and 140 provide a constriction as the water and exhaust gases leave the combustion engine of genset 10. The rings help form the water into water droplets and mix the  
15 gas with the water so as to reduce noise generated by the combustion engines. The constriction provided by rings 130, 140 also increases the velocity of the exhaust gas to more effectively pick up drops of water from the bottom of the tube 100 and hose 30 and to be able to carry the water with the gas. Moreover, these water droplets can help absorb sound. Also, the droplets help cool the exhaust gas. Cooler gases have  
20 shorter sound waves which are easier to attenuate. Moreover, the rings themselves restrict the sound-dampening device which increases attenuation. These factors, among others, provide for the sound dampening properties provided by exhaust tube 100.

Again, the exhaust assembly of Figures 2-5 includes an exhaust tube 100 that  
25 is installed directly to the exhaust of the genset 10. A standard flexible, marine exhaust hose 30 (Figure 1) can be installed between exhaust tube 100 and muffler 40. As can be seen in Figs. 9-10, which will be discussed in detail below, when the exhaust tube 100 is installed, the radiated exhaust noise from the industry standard

hose 30 is reduced almost to the level of an exhaust hose wrapped in a lead sheet and one-inch fiberglass. Thus, the radiated noise from the hose is no longer a major overall noise issue. Moreover, as noted above the tube 100 does not change the overall appearance of the genset and can be installed by the genset manufacturer.

- 5 Thus, the boat builder does not have to do any additional work or invest time and money in modifying the exhaust.

Figures 6-8 show an exhaust assembly according to one embodiment. The exhaust assembly of Figures 6-8 includes a modified flexible exhaust hose 200. In one embodiment, genset 10 of Figure 6 does not include an exhaust tube 100 as  
10 described above. Instead, flexible hose 200 is coupled to a standard genset exhaust 202. In this example, the sound-dampening device of the system includes flexible exhaust hose 200 connected between the genset exhaust and muffler 40.

As shown in Figure 7 and 8, flexible exhaust hose 200 includes a tubular hose body 210 with internal spaced rings 220. In one example, rings 220 are  
15 mounted to an inner diameter surface 215 of the hose body 210 and are evenly spaced about 4-½ inches apart throughout the length of the hose (which can be about 6 feet or less). In other embodiments, the rings can be spaced between four and five inches apart. The rings 220 have an outer diameter 225 the same size as the inner  
20 inner diameter 215 of hose body 210. Rings 220 have an inner diameter smaller than the inner diameter 215 of hose body 210. For example, the inner diameter of hose body 210 can be about 2 inches and the inner diameter of the rings 220 can be about 1 to 1-1/2 inches.

Figure 7 shows a side view of exhaust hose 200 in accordance with one embodiment. Figure 8 shows a section view of the exhaust hose. Rings 220 are  
25 adapted to change the exhaust gas flow and mixing it with water so as to reduce noise generated by the combustion engine. Rings 220 provide a constriction as the water and exhaust gases leave the combustion engine of genset 10. The rings help form the water into water droplets and mix the gas with the water so as to reduce

noise generated by the combustion engines. Without the rings the water would mostly stay on the bottom of the hose. The constriction provided by rings 220 also increases the velocity of the exhaust gas to more effectively pick up drops of water from the bottom of the hose and to be able to carry the water with the gas.

- 5 Moreover, these water droplets can help absorb sound. Also, the droplets help cool the exhaust gas. Cooler gases have shorter sound waves which are easier to attenuate. Moreover, the rings themselves restrict the sound-dampening device which increases attenuation. These factors, among others, provide for the sound dampening properties provided by exhaust hose 200.

- 10 Exhaust hose 200 that can be used by a boat builder instead of the industry standard exhaust hose to reduce the exhaust noise radiated from the hose. As can be seen in Figs. 9-10, when the hose 200 is installed, the noise level is reduced almost to the level of that of a flexible exhaust hose wrapped in a lead sheet and 1-inch fiberglass. The radiated exhaust noise from this modified flexible hose is no longer  
15 a major noise source and the overall noise level of the genset is reduced. The example hose 200 is interchangeable with industry standard hoses (for example, an outer diameter of about 2 inches and a length of usually 6 feet or less). The hose 200 can be used on almost any manufacturer or model genset.

- Figures 9 and 10 show graphs depicting exhaust system noise tests for the  
20 exhaust tube 100 and the exhaust hose 200 discussed above. The graphs display one meter A-weighted four-side average sound pressure level frequency spectrums of a gasoline marine genset with different external exhaust system configurations. The frequency spectrums in Figure 9 have the genset load at 8 kW and the frequency spectrums in Figure 10 have the genset loads at 10 kW. All the tested exhaust  
25 configurations include a two-inch diameter, six-foot flexible exhaust hose, water lift muffler, water separator, and infinite open tube exhaust. The baseline frequency spectrum 902 (diamonds) has a typical flexible exhaust hose wrapped in lead and fiberglass. The frequency spectrum 904 (squares) has an unwrapped standard

flexible exhaust hose. The frequency spectrum 906 (cross-marks) uses a three-foot length of flexible exhaust hose with internal rings every 5 inches and a three-foot length of standard flexible hose in series. The frequency spectrum 908 (triangles) has an unwrapped typical exhaust hose and an exhaust tube 100 with internal rings  
5 such as installed in Figure 2.

The radiated exhaust noise from the industry standard flexible exhaust hose is predominant in the frequency range of 1 kHz and above. Comparing the frequency spectrums of the different configurations, it can be seen that the radiated exhaust noise from the flexible exhaust hose in the frequency region of 1 kHz and  
10 above is significantly reduced when the standard flexible exhaust hose is wrapped or when the flexible exhaust hose with rings is installed or when the exhaust tube with rings is installed. This reduction would be even more dramatic if the frequency spectrum of only the exhaust side of the genset were compared instead of the average of four sides as shown here. The reduction would also be more dramatic if  
15 the frequency spectrum was linear not A-weighted as shown. The A-weighting reduces the noise contribution of frequencies above 2 kHz. A linear frequency scale better represents the noise quality improvement due to installing the modified exhaust hose and the modified exhaust tube.

In further embodiments, the exhaust components discussed herein can be  
20 used on any marine combustion engine to reduce the radiated exhaust noise from a flexible marine exhaust hose.

The above description is intended to be illustrative, and not restrictive. Many other embodiments will be apparent to those of skill in the art upon reviewing the above description. The scope of the invention should, therefore, be determined  
25 with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled.